581

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PROCEEDINGS

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PHOTOGRAMMETRY AND ITS APPLICATION

by A. O. Quinn, A.M. ASCE

SURVEYING AND MAPPING DIVISION

{Discussion open until April 1, 1955}

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PHOTOGRAMMETRY AND ITS APPLICATION

A. O. Quinn,[1] A. M. ASCE

In the past twenty-five to thirty years new surveying methods based upon the use of aerial photography have gradually evolved to the point where they offer definite and distinct advantages to the Civil Engineer. Members of our Society have had the opportunity of reading in "Civil Engineering" the description of many engineering projects that have made use of aerial photographs to produce topographic and planimetric maps in minimum time periods and at amazingly low costs. Reliable maps have been made for highway and railroad locations, housing and industrial sites, city planning and rural developments and many other engineering projects.

As members of the Surveying and Mapping Division of the American Society of Civil Engineers, we are not surprised to learn of these developments in the uses of photography - in fact, many of us have been directly concerned with the production or the uses of maps that were prepared by photogrammetric processes. However, frequently we have found that many of our fellow engineers do not embrace our confidence in photogrammetric methods, nor do they feel that the "new fangled" photographic ideas are based upon sound mathematical theories which would allow a solution comparable with the "old time" methods. In short, the photogrammetrist finds that he has a selling job to do to convince the "powers that be" that he has a scientific tool that can accurately and economically solve many surveying and mapping problems.

I should like to arm you with a few facts concerning photogrammetry to assist you in your photogrammetric sales program if you have one.

First, let's take the defensive position: Photogrammetry has been described as a "poorly conceived process of utilizing a camera, known to have various distortions of lens and film, to produce a photograph of unstable characteristics from which pseudo-engineers claim to produce an orthographic portrayal of the terrain. The photograph is a perspective view of the ground and terrain variations are shown as flat surfaces; the photograph may even be tilted to further distort the terrain and render a stereoscopic examination of the area of little value except as a parlor novelty."

I regret to say that the above comments have actually been given to me by men who have sincerely doubted the scientific value of photogrammetry. Two years ago, I was practically run out of the highway engineering department of one of our states by a group of engineers who were convinced that I was talking utter foolishness when I showed them accurate topographic maps which were prepared through photogrammetric methods. I might add that after a period of serious discussion, these engineers agreed to try a sample photogrammetric mapping area, and they were amazed at the results obtained. This group is now a firm supporter of photogrammetry.

Basically, photogrammetry is the new discovery of an old science - spatial geometry. It is true that we clothe our basic theorems with modern terminology, such as tilt and relief displacement, stereoscopic base, focal length,

1. Chief Engr., Aero Service Corp. Philadelphia, Pa.

flight height, "y" parallax, coordinates of the principal point, etc., but we are still referring to essential elements that enable us to orient a plane surface, the photograph, in space. Modern spatial geometry requires us to produce a photograph that is taken by a precision mapping instrument - the aerial camera - from an aircraft that is especially designed and equipped to produce a reasonably stable aerial platform from which highly skilled technicians can comply with detailed and specific requirements for photographic coverage. The aerial camera gives us the means of recording a photograph whose internal geometric characteristics are known - that is, focal length and optical centering. Optical and mechanical problems of lens distortion, shutter speeds, diaphram openings, film flatness, film winding, view finding and many other technical requirements are solved by the precision camera. These many precise requirements make the camera far more expensive and complicated than our very best theodolites. The recording medium, the aerial film, is the result of almost fifty years of research and development to achieve an economically feasible base giving a minimum of distortion under maximum ranges of humidity and temperature.

It is true that the resulting aerial photograph is a perspection view of the terrain. However, it is a flat surface, and we can determine its spatial orientation by either analytical computations or through the use of highly precise stereoscopic mapping instruments which can optically and graphically solve space intersection problems. Because precise instruments are used, we can obtain United States Bureau of Standards tests to determine lens distortions both in our aerial cameras and in our mapping instruments.

Slide #1 shows in diagrammatic form the elemental geometry of the aerial photograph in space. Without going into any mathematical proofs, I think you can see that the so-called "relief displacements" are really simple geometric relationships which can be solved by similar triangles to determine true ground survey positions on the photograph.

Now (Slide #2) if we were to introduce tilt into our spatial system, we do complicate the problem, but we certainly do not create a situation which defies solution. Ground control in the form of horizontal and vertical identified points are required. These data are not always requ[illegible] on every photograph since photogrammetry has devised methods of "bridging" whereby ground control can be obtained on some photographs, but on intermediate photographs positions and elevations may be determined photogrammetrically. There are many classical analytical solutions to the so-called "spatial resection" problem. This problem can be worked either on a single photograph or in pairs of overlapping pictures. In general, the latter approach is now preferred.

Highly precise stereoscopic instruments such as the Wild A-7 or Zeiss Stereoplanigraph (Slide #4) are used in the "bridging" work previously mentioned. These instruments are equipped with tilting motions that enable an operator to obtain and record the relative orientation between any two overlapping photographs through the recovery of the geometric conditions that existed at the time each photograph was exposed. This is accomplished by optically measuring and determining the spatial relationship between each exposure. In a like manner, the relative orientation may be correlated to the previously established ground control to produce an absolute orientation of the spatial model.

Other instruments, such as the Wild A-6 and A-8 Kelsh Plotter (Slide #5) and the Multiplex also solve the problem of spatial orientation with sufficient accuracy to permit the preparation of topographic maps. These instruments require more ground control than the more precise Wild and Zeiss instruments. For some work the Multiplex can also be used for "bridging." Many

organizations use Bridging instruments to obtain horizontal and vertical control for use in the Kelsh Plotters and other similar plotting instruments.

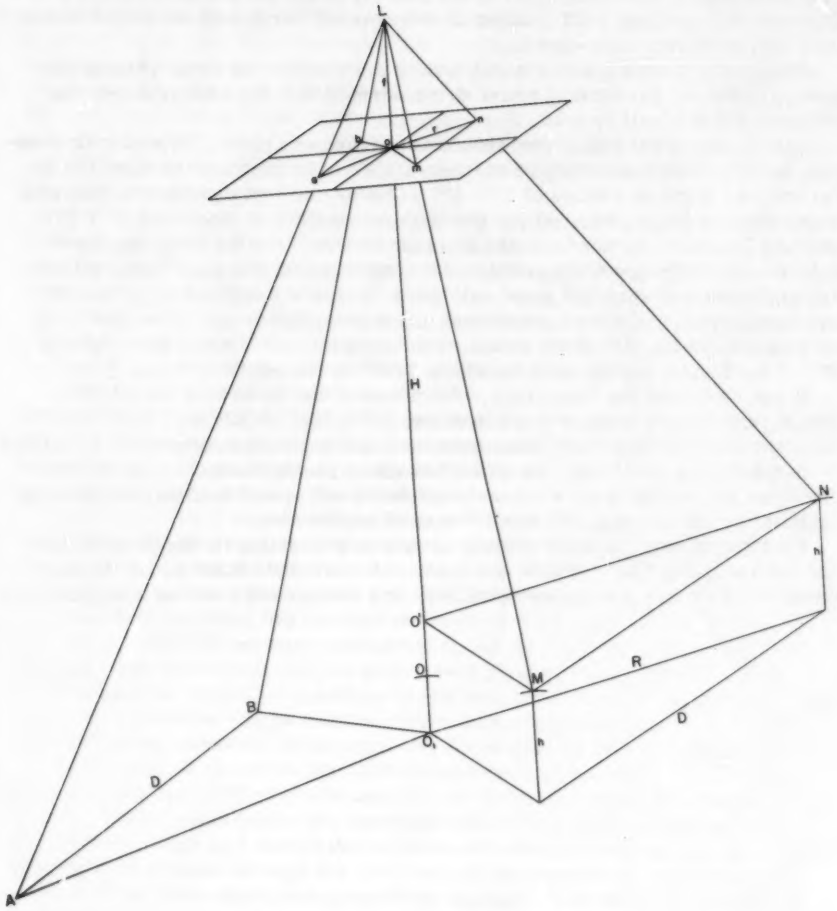
With the spatial orientation completed, it is a simple matter to convert the "perspective" photograph into an "orthographic" map. In diagrammatic form, the two overlapping photographs may be re-projected (Slide #6) to form an exact small scale model of the terrain covered by both photographs. By interposing an optically reading and calibrated measuring device the intersection of similar light rays may be found and vertically projected to our mapping base sheet. Basically, this is the method of the plane table, though in stereoscopic mapping each contour is determined throughout its length rather than sketched from spot-shots.

Admittedly, I have given you but a very brief outline of basic photogrammetry, however, I trust that I have demonstrated that the criticisms of the skeptics are not well founded.

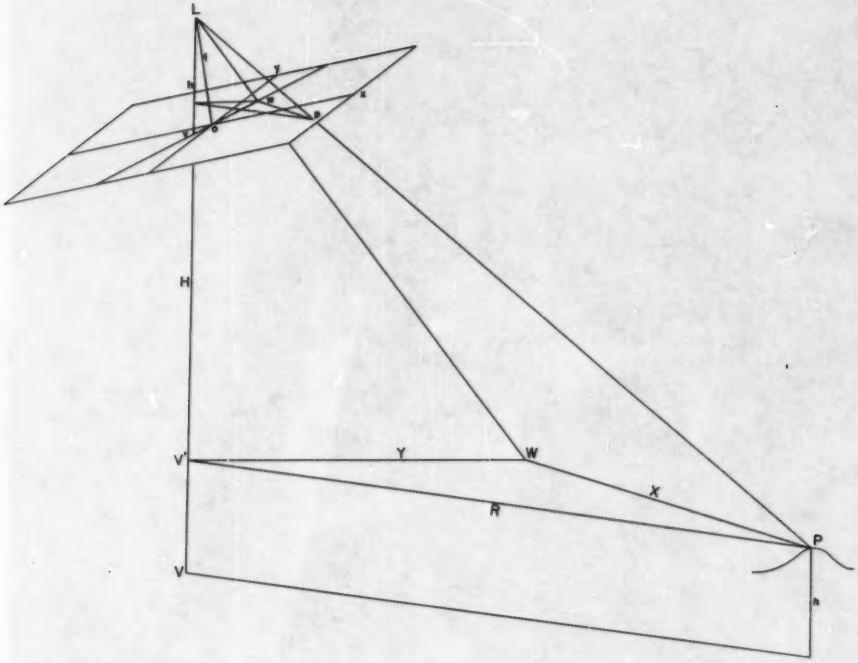
Our Company has completed thousands of square miles of topographic mapping for the most discerning of engineers. We have produced to standard accuracy city maps at a scale of 1" = 40' showing one foot contours; detail site maps such as those prepared for the H-Bomb project at a scale of 1" = 100' showing 2' and 5' contours; highway maps on which the locating engineers determined cross sections; profiles for transmission and pipe lines; volume determinations of coal and wood pulp piles for tax and inventory purposes; and topographic maps for government and exploration usage. Standard map accuracy calls for 90% of all contours to be within 1/2 contour interval and 90% of horizontal positions to be within 1/40" at the published map scale.

If you will read the September, 1953 issue of the American Society of Photogrammetry's quarterly publication, PHOTOGRAMMETRIC ENGINEERING, you will see that Europeans have been using photogrammetry in the fields of dentistry and medicine. An allied branch of photogrammetry, photo interpretation is proving to be a valuable aid in forestry, soil studies, engineering estimating and planning and in all forms of exploration.

Photogrammetry is here to stay; we are now standing on the ground floor and we are going "up". There are many new uses and techniques to be discovered. How can photogrammetry help you in your engineering assignments?



Slide 1.



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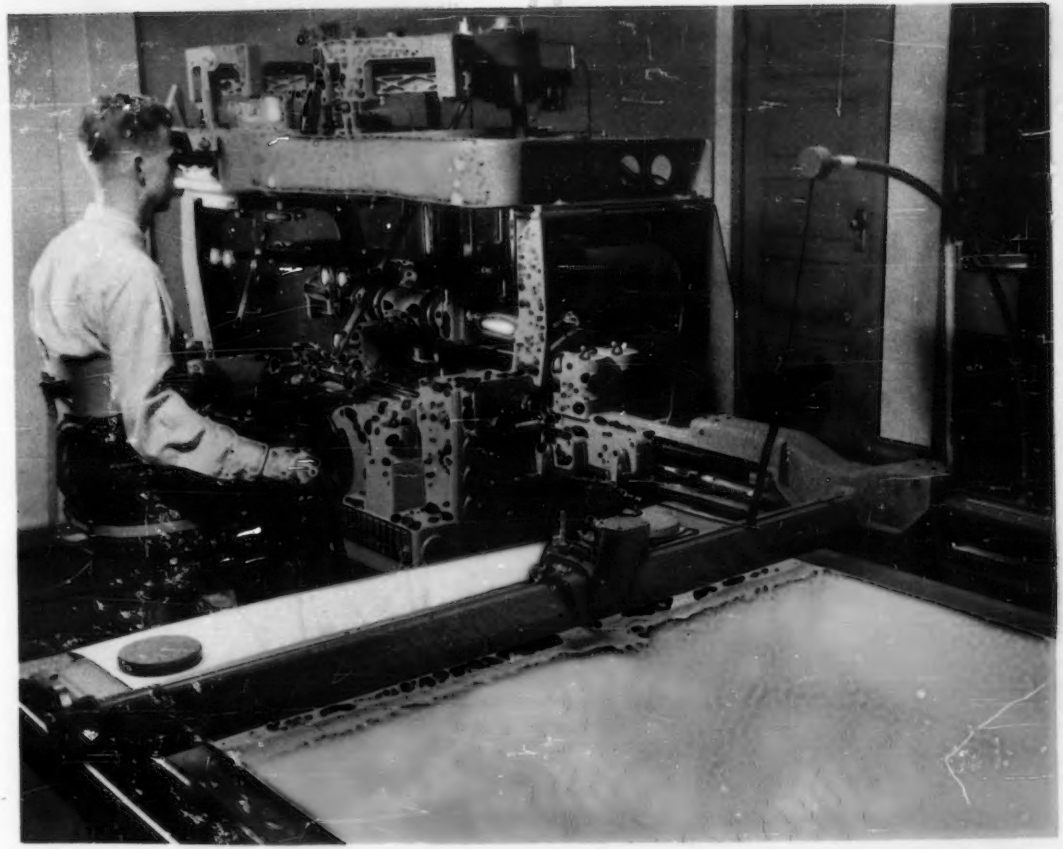
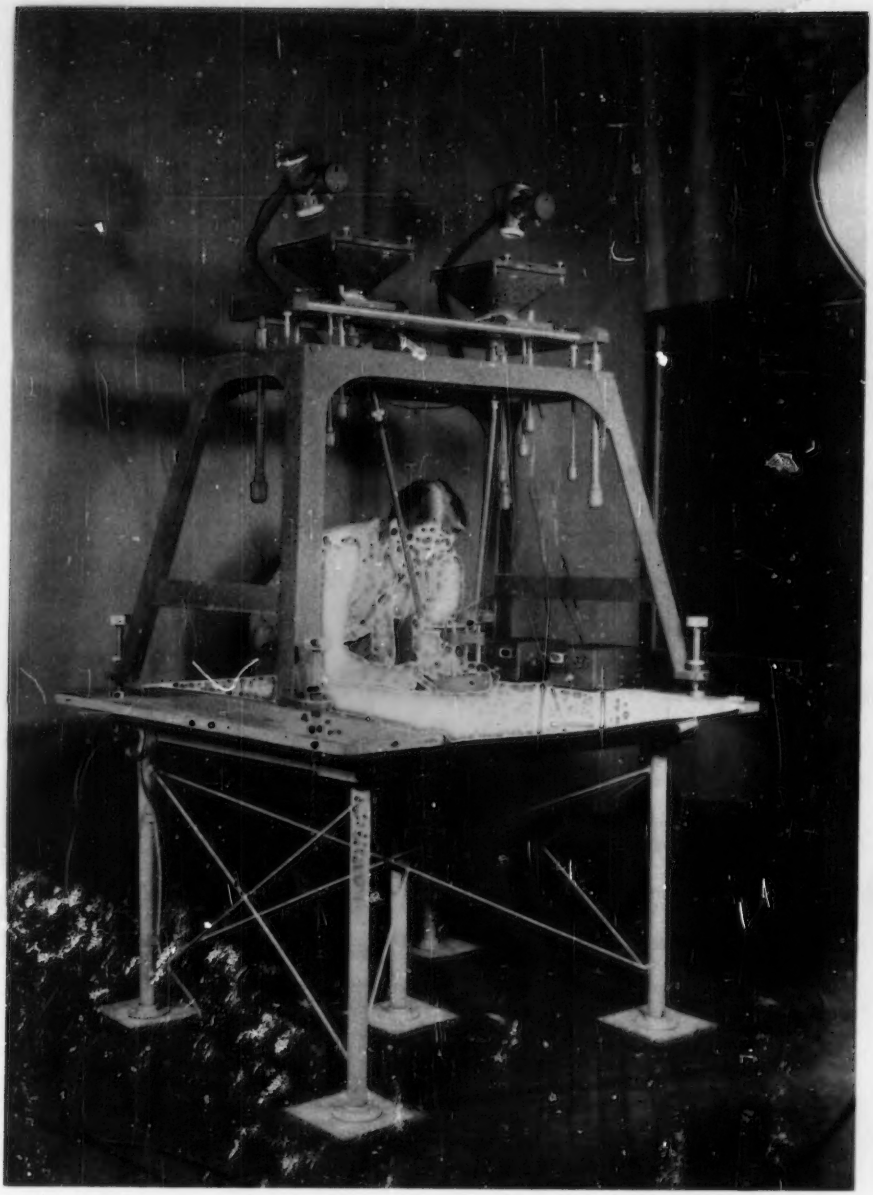
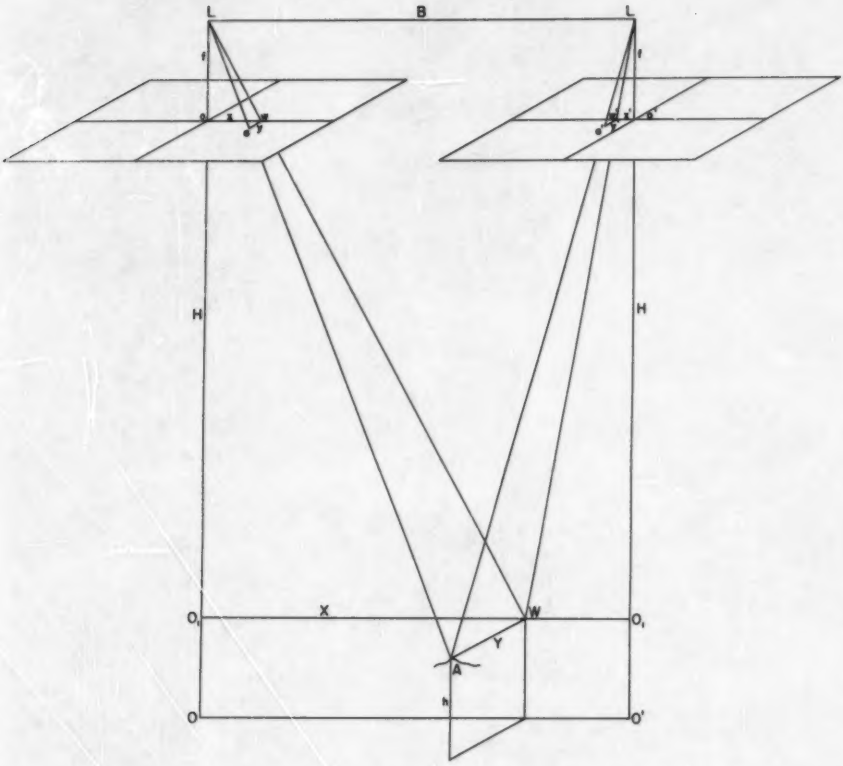


Slide 4. A-7

581-6



Slide 5. Kelsh Plotter



Slide 6.

PROCEEDINGS-SEPARATES

The technical papers published in the past year are presented below. Technical-division sponsorship is indicated by an abbreviation at the end of each Separate Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

VOLUME 79 (1953)

DECEMBER: 359(AT), 360(SM), 361(HY), 362(HY), 363(SM), 364(HY), 365(HY), 366(HY), 367(SU)[c], 368(WW)[c], 369(IR), 370(AT)[c], 371(SM)[c], 372(CO)[c], 373(ST)[c], 374(EM)[c], 375(EM), 376(EM), 377(SA)[c], 378(PO)[c].

VOLUME 80 (1954)

JANUARY: 379(SM)[c], 380(HY), 381(HY), 382(HY), 383(HY), 384(HY)[c], 385(SM), 386(SM), 387(EM), 388(SA), 389(SU)[c], 390(HY), 391(IR)[c], 392(SA), 393(SU), 394(AT), 395(SA)[c], 396(EM)[c], 397(ST)[c].

FEBRUARY: 398(IR)[d], 399(SA)[d], 400(CO)[d], 401(SM)[c], 402(AT)[d], 403(AT)[d], 404(IR)[d], 405(PO)[d], 406(AT)[d], 407(SU)[d], 408(SU)[d], 409(WW)[d], 410(AT)[d], 411(SA)[d], 412(PO)[d], 413(HY)[d].

MARCH: 414(WW)[d], 415(SU)[d], 416(SM)[d], 417(SM)[d], 418(AT)[d], 419(SA)[d], 420(SA)[d], 421(AT)[d], 422(SA)[d], 423(CP)[d], 424(AT)[d], 425(SM)[d], 426(IR)[d], 427(WW)[d].

APRIL: 428(HY)[c], 429(EM)[c], 430(ST), 431(HY), 432(HY), 433(HY), 434(ST).

MAY: 435(SM), 436(CP)[c], 437(HY)[c], 438(HY), 439(HY), 440(ST), 441(ST), 442(SA), 443(SA).

JUNE: 444(SM)[e], 445(SM)[e], 446(ST)[e], 447(ST)[e], 448(ST)[e], 449(ST)[e], 450(ST)[e], 451(ST)[e], 452(SA)[e], 453(SA)[e], 454(SA)[e], 455(SA)[e], 456(SM)[e].

JULY: 457(AT), 458(AT), 459(AT)[c], 460(IR), 461(IR), 462(IR), 463(IR)[c], 464(PO), 465(PO)[c].

AUGUST: 466(HY), 467(HY), 468(ST), 469(ST), 470(ST), 471(SA), 472(SA), 473(SA), 474(SA), 475(SM), 476(SM), 477(SM), 478(SM)[c], 479(HY)[c], 480(ST)[c], 481(SA)[c], 482(HY), 483(HY).

SEPTEMBER: 484(ST), 485(ST), 486(ST), 487(CP)[c], 488(ST)[c], 489(HY), 490(HY), 491(HY)[c], 492(SA), 493(SA), 494(SA), 495(SA), 496(SA), 497(SA), 498(SA), 499(HW), 500(HW), 501(HW)[c], 502(WW), 503(WW), 504(WW)[c], 505(CO), 506(CO)[c], 507(CP), 508(CP), 509(CP), 510(CP), 511(CP).

OCTOBER: 512(SM), 513(SM), 514(SM), 515(SM), 516(SM), 517(PO), 518(SM)[c], 519(IR), 520(IR), 521(IR), 522(IR)[c], 523(AT)[c], 524(SU), 525(SU)[c], 526(EM), 527(EM), 528(EM), 529(EM), 530(EM)[c], 531(EM), 532(EM)[c], 533(PO).

NOVEMBER: 534(HY), 535(HY), 536(HY), 537(HY), 538(HY)[c], 539(ST), 540(ST), 541(ST), 542(ST), 543(ST), 544(ST), 545(SA), 546(SA), 547(SA), 548(SM), 549(SM), 550(SM), 551(SM), 552(SA), 553(SM)[c], 554(SA), 555(SA), 556(SA), 557(SA).

DECEMBER: 558(ST), 559(ST), 560(ST), 561(ST), 562(ST), 563(ST)[c], 564(HY), 565(HY), 566(HY), 567(HY), 568(HY)[c], 569(SM), 570(SM), 571(SM), 572(SM)[c], 573(SM)[c], 574(SU), 575(SU), 576(SU), 577(SU), 578(HY), 579(ST), 580(SU), 581(SU), 582(Index).

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c. Discussion of several papers, grouped by Divisions.
d. Presented at the Atlanta (Ga.) Convention of the Society in February, 1954.
e. Presented at the Atlantic City (N.J.) Convention in June, 1954.

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